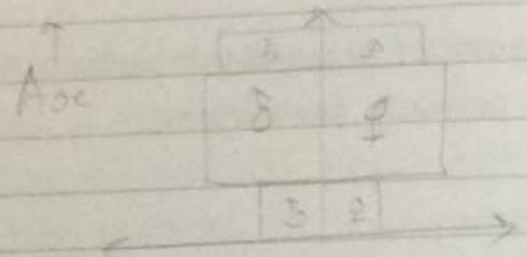


Generation time

The avg span of time b/w the birth of individuals and the birth of their offspring

- Strongly related to body size.
- A shorter gen. time usually results in faster popl^n growth, assuming birth rate > death rate & all other factors being equal.

Sex Ratio

The proportion of individuals of each sex found in a population.

- The no. of ♀s is usually directly related to the expected no. of births.
- The no. of ♂s may be less significant since 1♂ may mate with several ♀s.

nonmonogamous spp.

Life tables and survivorship curves

- Life tables describe how birth rates and death rates vary with age over a time period corresponding to maximum life span.

→ Constructed by following the fate of a cohort, a group of individuals of the same age, from birth until all are dead or by using the age specific birth & death rates in a popl^n during a specified time.

Survivorship : The proportion of the original cohort who survive to age x

Mortality : The proportion of individuals of age x who die before reaching age $x+1$

Fecundity : Defined differently as required

Life expectancy : ~~How long~~ To what age does an average individual of age x live upto?

→ Area is divided into smaller squares called 'quadrat'
→ Only relevant for non-motile organisms.
→ Each quadrat is individually counted or some randomly chosen quadrats are counted.

→ A Poisson distribution is used

$$P(x) = \frac{1}{x!}(\mu^x e^{-\mu})$$

where we know $\mu = \sigma^2$

Then, we check

$\frac{S^2}{\bar{x}} = 1$ If so, then random
If >1, then clumped
If <1, then uniform

Demography

Study of factors that affect birth & death rates in a population.

- Age structure & sex ratio

Many populations have overlapping generations where individuals of more than one generation coexist.

→ Exceptions include spp. in which all of the adults reproduce at the same time,

structure in most populations.

Age structure

Relative nos. of individuals of each age in a population.

- Generations overlap when average lifespan is greater than the time it takes to mature and reproduce.

- Every age group has a characteristic birth and death rate.

=> Birth rate greatest for those of intermediate age.

- Population pyramid

ECOLOGICAL INTERACTIONS
- Mutualism
- Parasitism
- Commensalism
- Predation

	Megachiroptera	Microchiroptera
1	Fruit bats / Megabats	Insectivore bats / Microbats
2	Single family, spp. diversity (200)	17 families, spp. diversity (1000)
3	Big eyes; Small ears	Small eyes; Big ears
4	No echolocation — High olfactory sensitivity	Have echolocation capability
5	Helps in pollination & seed dispersal.	Help in pest control

(A) Ball-badminton tree secretes nectar from their flower only at night, attracting fruit bats and are majorly pollinated by bats alone.

(B) Nocturnal anthesis in *Madhuca latifolia* (Mahua) are exclusively pollinated by bats.

(C) A spp. of Philostomid bat, Anoura *fistulata* has been studied by a group in Univ. of Missouri

» The bat preys on several insects but also supplements its diet by consuming nectar from flower.

» It has an extraordinarily long tongue, which the

Chiroptechory

» Some spp. of fruit bats such as flying foxes cover long distances each night, defecating in flight, and scattering far more seeds across cleared areas than even birds.

» Many bat-dispersed seeds are from hardy pioneer plants, the first to grow in the hot, dry conditions of clearings with up to 95% chance of germination.

» Frugiverous bats play imp. role in the early stages of forest succession.

Birds exhibit in-situ feeding while bats fly with the fruits ex-situ feeding, hence better dispersers than birds.

→ Frequency dependent selection
→ Sympatric requirement

Müllerian mimicry

» Two aposematic noxious forms conform to the same colouration/patterns of warning signal in order to avoid a common predator.

» Shared cost & benefit.

Polymorphism

- Visual predators that exploit polymorphic prey suffer from reduced performance.

- This happens due to the reduction of predator's ability for associative learning due to an overabundance of form.

- Support for hypothesis that prey colour polymorphism may afford

- Microbats use echolocation to navigate and find food. These nocturnal predators can use echolocation to not only detect movements but also its shape, size and texture.

- Many moths are eared. They can employ these to hear their hunters and device counter strategies.

- Escape flight in moths is one of the many antipredator strategies of moths against their predator.

- Escape flight are erratic, with zig-zag patterns, loops, sharp turns.

- Prey startling moths.

Predator activity	Predator adaptation	Prey adaptat
	Improved sensory acuity to find prey	
	Search in prey-abundant areas	
	Learning & pattern recognition.	
	Motor skills speed,	

Measuring density

It is usually impractical or impossible to count all individuals in a population, so ecologists use a variety of sampling techniques to estimate densities and total popl^{n} size

- May count all individuals in a sample of representative plots. Estimates become more accurate as sample plots increase in size or number.

- May estimate by indirect indicators such as number of nests or burrows, or by droppings or tracks.

- May use mark recapture method

$$\frac{\left(\begin{array}{c}\text{No. of individuals}\\ \text{marked}\end{array}\right)}{\left(\text{Popl}^{n}\text{ size}\right)} = \frac{\left(\begin{array}{c}\text{No. of individuals}\\ \text{bearing the mark}\\ \text{in recapture}\end{array}\right)}{\left(\begin{array}{c}\text{No. of recaptured}\\ \text{individuals}\end{array}\right)}$$

† Assumes marked individuals have same prob. of being trapped as unmarked individuals.

* Marking doesn't affect fitness of the individuals.

* No birth, death, migration between marking and recapture.

† The mark must not wash off or wear away.

Patterns of dispersion

>> A popl^{n}'s geographical range is the geographical limits within which a population lives.

- Local densities may vary substantially because not all areas of a range provide equally suitable habitat.

>> Individuals exhibit a continuum of 3 general patterns of spacing in relation to other individuals: *clumped*, *uniform* and *random*.

CLUMPED	UNIFORM	RANDOM
Individuals are aggregated in patches.	May result from antagonistic interactions b/w individuals of the popl^{n}	occurs in absence of strong attractions or repulsions among individuals.
Resource must be heterogeneously distributed.	Eg: Competition for some resource/social interactions that set up territories for individuals	Not very common in nature
May be associated with mating or other social behaviour in animals.		

EVOLUTIONARY

» Initially, even slightest & very crude adaptations could confer a selective advantage

» Improvements in one of the two parties (predator/prey), then selected for improvement in the other

» This results in improved counter-adaptations

Signal diversity and function

→ Enormous diversity of signals in nature
→ Diverse structure & diverse fxn
→ " tasks in the daily lives of animals

Mate attraction

→ Nuptial gifts
→ Olfactory attraction
→ Visual attraction (Bower bird)

→ Singing & Dancing
  • In order to increase its song repertoire size, the lyre bird mimics the calls of sounds it hears

Ways of animal communication

» Gestural / Tactile
» Olfactory
» Visual
» Vocal

» Theory of natural selection – Inadequate

» Sexual selection: 'the advantage which certain individuals have over other individuals of the same sex and spp., in exclusive relation to reproduction'.

» Male-male competition OR ♀ choice

Fisher's runaway selection

• Slight exaggerated characters indicators of ♂ quality.

• ♀s prefer ~~for~~ honest indicators

• ♂s with exaggerated character get to reproduce; sons have exaggerated characters, daughters have a preference for it.

• This feedback loop continues resulting in superlative

- ♀s that delay reproduction tend to be larger due to energy used for growth & maintenance; older (larger) ♀s produce larger clutches and appear to maximise their reproductive output by delaying.

Models of population growth

I Exponential

N: No. of individuals in a popl^n

$$\frac{dN}{dt} = B - D$$

B: no. of births; D: no. of deaths

$B = bN$ — b: Per capita birth rate

$D = dN$ — d: Per capita death rate

$$\Rightarrow \frac{dN}{dt} = N(b-d) = Nr_{max}$$

r_{max} : b-d → Intrinsic rate of growth

$$\frac{dN}{dt} = Nr_{max}$$

$$\Rightarrow \int_{N_0}^{N_t} \frac{dN}{N} = \int_{t_0}^{t} r_{max}\, dt$$

$$\ln\left(\frac{N_t}{N_0}\right) = r_{max}(t_0 - t)$$

$$\Rightarrow N_t = N_0 e^{r_{max}(t_0 - t)}$$

$$N_t = N_0 e^{rt}$$ [Exponential model]

Assumptions of exponential model
- Large space
- Few individuals
- Unlimited resources

II Logistic

k: carrying capacity

[No. of individuals of a popl^n the environment can "carry".]

Hence — $r_{realised} = r_{max}\left(\frac{k-N}{k}\right)$

k = Pop size when $r_{realised}$ is 0

$$N_t = \frac{N_0 e^{rt}}{1 + \left(e^{rt} - 1\right)\left(\frac{N_0}{k}\right)}$$ [Logistic model]

varying pressures of natural selection

- Some animal spp. hatch in one type of biome, migrate to another where they mature for several years, then return to the initial biome for a single massive reproductive effort, then die.

- other animal spp. hatch & mature rapidly in a single habitat, then have small reproductive efforts each year for several years.

Even though life history traits vary widely, there are some basic patterns –

- Life histories often vary in parallel with environmental factors. Eg: clutch sizes increase with latitude –

» Tropical birds lay fewer eggs than those in higher latitudes which reflects the no. of offspring that can be successfully fed.

» Since day lengths are longer at higher latitudes than the tropics during offspring rearing season parent birds can

layed

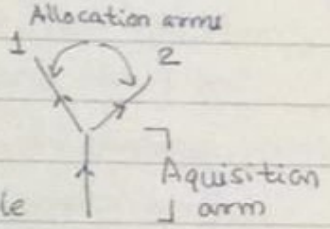
life expectancy

· Allocation of limited resources

» A life history based on heritable traits that result in producing the most reproductively successful descendants will become more prevalent in a popl^n.

» Y model resource allocation

A successful life history resolves the conflict b/w limited resources & competing fx^3 –



» Time, energy, and nutrients used for 1 fx^n aren't available for other fx^{n}s

» The integrated life histories seen in natural popl^n balance the investment in the no. of offsprings produced against the prospects of future reproductions.

⇒ In general, organisms that produce fewer offspring during a reproductive effort survive longer & have more reproductive episodes.

Beauty v/s Honesty

- According to Fisher's theory, extravagant characters evolve INSPITE of reduction in fitness.

Handicap principle

→ Signals are honest or reliable when they signal the true quality of signaller.
→ Honest signals must be costly.
→ Only high quality signalers can 'afford' to produce costly signals.

→ Peacocks with elaborate trains have been found to be better survivors with larger fat reserves and higher levels of immunocompetence.

→ Elaborate train is an honest indicator of quality.

» It is the study of populations in relation to the environment. It includes environmental influences on population density and distribution, age structure, and variations in population size.

Population: Individuals of one sp. simultaneously occupying the same general area, utilising the same resources, and influenced by similar environmental factors.

No popl^n can continue to grow indefinitely -

- Many popl^{n}s remain relatively stable over time with only minor increases & decreases
- Other popl^{n}s show dramatic increases followed by equally dramatic decreases.

Important

POPULATION DENSITY	POPULATION DISPERSION
No. of individuals per unit area/vol.	The pattern of spacing among individuals

Trade-off
↳ Genetic

Number of reproductive episodes per lifetime.
2 extremes are found in life history strategies where there is a trade-off b/w fecundity and survival prob.

Semelparity
Type of LH in which organisms invest most of their energy in growth & development, then expend that energy in a single reproductive bout.

Iteroparity
Type of LH where organisms reproduce iteratively, each iteration with very few progeny.

Expected when there is a high cost to parents to stay alive b/w broods or if there is a trade off b/w fecundity / survival.

Seen in annual plants, salmon and some perennial plants such as bamboo/century plant.

Juvenile phases may be

Clutch size
It is the no. of offspring produced at each reproductive episode.

- Organisms with a low prob. of surviving to the next reproductive season usually invest more energy into producing a large no. of offspring.
- Organisms with a high prob. of survival invest less energy and produce fewer offspring.
- Clutch size may vary seasonally within a single popl^n in some spp.

Age at first reproduction
The timing of the 1st reproduction greatly influences the ♀'s lifetime reproductive output in organisms that have several reproductive episodes during their lifespan.

- Balances the cost b/w current reproduction and survival plus future reproduction.
- Reproduction at a younger than average age may reduce a ♀'s reproductive potential by reducing the amount of energy available for growth & maintenance.

benefits and other does not benefit but is not harmed either.

Shark & Remora fish
- Free ride
- Leftovers from shark

Orchids growing on branches of trees
- Epiphytic

Parasitism
- Mosquitoes
- Brood parasitism

Predation
» Visual predator : Search image Pattern matching
For the prey -
(i) Countering a search image in predators

Predator avoidance

1. Search for prey → Crypsis
2. Prey recognition → Mimicry / Polymorphism
3. Pursuit/Catching prey → Escape flights
4. Handling prey → 'Startle' response; Weapons of defence
   ↳ Active defence

Crypsis
Avoiding detection.
Eg : Camouflage

» Male shale grasshopper mimics the stones it sits on.

» A lichen spider camouflage on the bark of trees with lichen growth.

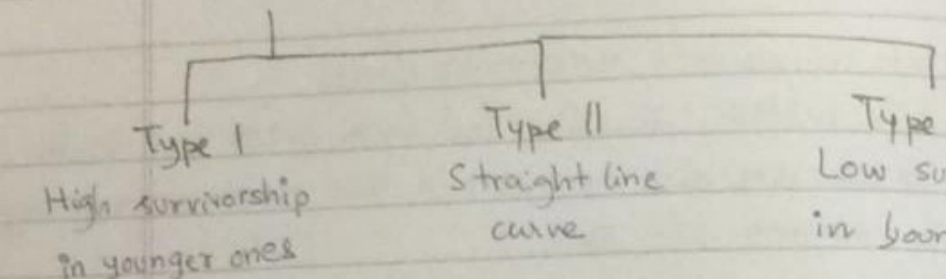
» Satanic leaf-tailed gecko (Madagascar)

Mimicry
A form of crypsis (usually visual) where an animal looks or behaves like another organism or object in order to avoid detection.

Can be used by prey or predator.

Batesian mimicry	Mullerian mimicry
Dishonest signal	Honest signal
A harmless spp. resembles a toxic spp that is noxious to predators	
Relies on associative learning of predators	

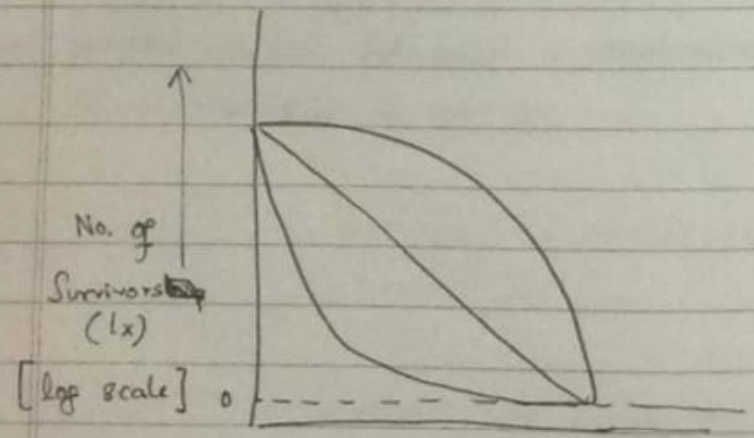
Survivorship curves plot the nos.



Many spp. exhibit curves b/w the basic types of survivorship curves and some have more complex curves

(i) Great tits show a high mortality rate in young birds (Type III) but a fairly ~~high~~ constant mortality (Type II) in adults

(ii) Some invertebrates show a "stair-stepped" curve with brief periods of high mortality during molts,



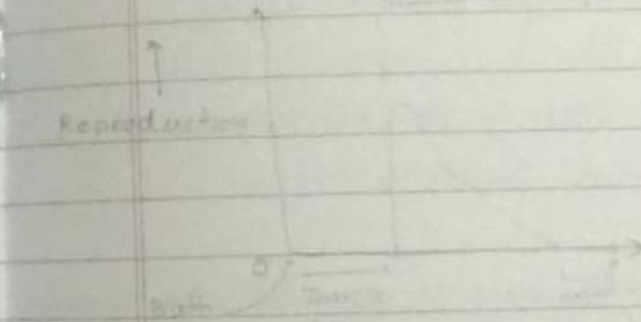
The traits that affect an organism's schedule of reproduction & death make up its life history

Variation in life history

Natural selection, working over evolutionary time, results in traits that affect an organism's life history

Life history

- An organism's schedule of reproduction and death
- These traits affect popl^n growth over time



Grandmother hypothesis

- Very long post reproductive age in ♀ humans

- They help rear their grandchildren

- WD Hamilton's 'inclusive fitne